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The state of the art Literature Review on Smart City

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Abstract: The use of new technologies in business models and infrastructure has been driven in part by the Internet and globalization. The next trend of innovations is likely to come from humans' ability to connect to machines and the data that comes from these connections. The IBM Intelligent Operation Center (IOC) is a "system of systems" that is not intended to replace an existing physical infrastructure that gathers raw data. Instead, it is intended to extract only the data necessary to optimize the operations of the organization. The types of data and integration into the IOC make efficient problem solving solutions readily available to city authorities. The user interface and standard operating procedure and the resource processing capabilities of the IOC indicate that this system is optimal for smart cities of the future with regard to improvement of quality of life and ease of navigation. The need for smart cities, universities, campuses, citizens, and students to drive growth of urban and regional economies is evident. In this article, a thorough analysis of the architectural design of an intelligent operational system is completed to present a smart solution for cities to unify departments and agencies under one umbrella.

Keywords: Intelligent Operation Center, Smart cities, Smart citizen, Simulation

1. Introduction:

Today's cities face significant challenges, such as increasing population, pollution, congestion, resource usage, lack of adequate physical and social infrastructures, sustainable economic growth, and increasingly stricter energy and environmental requirements [1,2]. According to the United Nations [3], more people live in urban areas than in rural areas. In 1950, only 30% of the world's population was living in an urban environment, but in 2018, this number increased to 55%. In 2030, it is expected to increase to about 60% [4] and by 2050, the projections point to about 68% of the world's population being urban [3]. The United Nations [3] states that "the growth in the urban population is driven by overall population increase and by the upward shift in the percentage living in urban areas". Together, these two factors can add about 2.5 billion to the world's urban population by 2050, with almost 90% of this growth happening in Asia and Africa [3]. The urbanization process is occurring at different rates, being considerably faster in developing regions than in the developed ones. Africa is expected to be the fastest urbanizing region and according to Joint Research Centre [5], in the last 25 years, the urban population has more than doubled in almost all countries across sub-Saharan Africa, although meanwhile, in many parts of North America and Europe, the urban population has been declining. In 2016, there were, globally, about 512 urban centers with at least 1 million inhabitants and 31 megacities with over 10 million inhabitants [6]. By 2030, these numbers are projected to increase to 662 urban centers and 41 megacities, most of which in developing regions [6].

Nowadays, cities are estimated to generate 80% of all economic growth [7], covering only about 3% of the land, but producing about 72% of all global greenhouse gas emissions [8]. All the continuous population growth, and especially in urban areas, put a lot of challenges in the design of cities and exceptional sustainability challenges, both on infrastructures and the environment [9]. The development challenges of cities have attracted many interdisciplinary fields of study. Computer Science is one of the multiple fields addressing city development challenges. The interest of Computer Science began at the end of the 20th century when cities were idealized to become a network of computers and other electronic based devices [10]. Nowadays, cities are composed of even more complex systems in constant evolution, in which the combination of multiple research areas is needed in order to overcome the arising endless challenges [10]. In order to make cities and communities more inclusive, safe, resilient, and sustainable, as per the "Sustainable Development Goal 11" of the 2030 Agenda for Sustainable Development [11], it is crucial to understand the key trends in the future of urbanization [4], and to evaluate city growth development and implementation measures to fulfill the multi-dimension human and sustainable requirements.

The "Smart City" concept is intended to address the referred challenges by identifying new and smart ways to manage the complexity of urban living and implement solutions for multidisciplinary problems ranging from energy consumption, resource management, environmental protection, security, quality of life, the e_ciency of urban operation, and the availability of a wide variety of services [9,12,13].

The estimated number of smart city implementations varies depending on the definition and extent of the elements included in the analysis. A Navigant Research global market report [14] estimated that in 2017, there were more than 250 smart city project implementations in 178 cities worldwide. Europe is the top-performing geographical area with 12 cities ranking among the top 25 smart cities ranked by the IESE Cities in Motion Index 2018 [15]. Europe is aiming to have about 300 smart cities by the end of 2020 and India plans to build about 100 smart cities by 2022, impacting a population of almost 1 billion people [16].

"Smart City" as a new research concept began in 1992 with the book entitled "The Technopolis Phenomenon: Smart Cities, Fast Systems, Global Networks" [10,17]. Since then, this research area has not only attracted different research areas, but also many stakeholders, from governmental organizations to industries and social society, supporting the growing interest of the "Smart City" concept, within the global sustainable development framework.

According to Mora [10] the "Smart City" research established itself as a new scientific field in the year 2009, but despite all the growing number of publications, the concept is far from having a clear and established definition. Many definitions for the concept have been developed, but so far none has been commonly accepted by the scientific community. It is common to see different interpretations according to the context of the publications [13,18]. The absence of such a definition has been pointed out in several publications, namely [1,10,19]. According to the bibliometric analysis of the literature published between 1992 and 2012 performed by Mora [10], there is a tendency among publications to differentiate themselves, being difficult to acquire a common agreement.

Some publications mostly see Smart City as a technological innovation whereas others see it as social innovation. There is the idealization of a Smart City being supported by a technological combination of different IoT devices forming a wireless sensor network (WSN), for numerous control and monitoring applications fields namely for utilities, security, asset tracking, and smart metering [20]. The bibliometric analysis of the literature developed by Mora [10] points out that "researchers seem to agree in picturing the smart city as an urban environment in which an ICT-driven approach to urban sustainability is activated". The same analysis states that there are although different research paths being followed. The two most cited groups of publications describe the smart city as a more techno-centric approach and the other, one of the most cited and influential documents in the area published between 1992 and 2012, Gainer [21], as a balanced combination of human, social, cultural, economic, environmental, and technological factors [10]. Technology should be seen as a means to achieve the outcomes of a Smart City implementation according to the needs of its location (environment, energy, people, business, governance, etc).

The Smart City concept is still evolving and there is not yet a commonly accepted worldwide definition, but it is quite clear that Smart Cities leverage information and communication technologies to enhance service levels, citizen well-being, sustainability, and economic development. Expanding the Smart City concept will, for instance, improve the existing infrastructures, increase the digitalization and integration of facilities and services, expand the use of collaboration tools and automated service management platforms, increase the safety of citizens and transportation, making cities more attractive for stakeholders, and living up to citizens' expectations. According to an OECD recent report [22], when well connected with inclusive growth objectives, Smart City implementations can, besides many other advantages, offer powerful tools to support the shift from in-person to remote service delivery, mitigating the fallout of the crisis on urban residents and businesses, including the most vulnerable ones, and empower new forms of local governance. However, the same report states as a possible threat to society the "increased inequality among digitally marginalized groups" and "possible abuse of citizen data, privacy and safety".

Different and distinct Smart City concepts and architectures have emerged during the past decades, but all of them visualize it as being composed of different inter-related components, such as data, economy, people, governance, mobility, environment, and living [13,23]. All of the components are related to different aspects of urban living, such as communication, industry, education, e-democracy, logistics and infrastructures, efficiency and sustainability, security, and quality [23]. All this diversity of components and related aspects has attracted multi-disciplinary approaches and science fields to the Smart City developments, which has contributed to the enrichment of scientific knowledge and increase and scale-up of innovative technology developments.

Despite all the different research paths and lack of commonly accepted definition in the trending Smart City concept, one point is clear; the impact evaluation of Smart City implementations is extremely valuable and strongly needed. Every impact evaluation has the principle of permitting the characterization of achieved levels of performance according to a certain target goal. This is crucial for the planning of the city further developments and upgrades, to assess the strengths and weaknesses, for comparison with other implementations and to inform the different interested stakeholders about the implementation status.

2. Related Work:

The rise of interconnectedness has created a redistribution of wealth and redefined the workforce of the future [1]. The shift in globalization has been largely propelled by the Internet, which has increased the rate at which people and business are connected, as well as, created a larger realm of competition where challengers can enter and disrupt economic markets and supply chains. As Davies notes, the Internet of Things references the mass connectivity of machine-augmented systems, processes and people to create value. As with all advancements in society, the Internet's growth and subsequent influential position into both economic and political arenas has been met with a mixture of enthusiasm and skepticism from businesses and institutions whose power and influence have been threatened [2]. Smart cities are critical to the digital economy and for the nation's capacity to compete globally, being those cities that exploit hyper-connectivity to meet real challenges such as mitigating the effects of urbanization, addressing added pressure for infrastructure and quality of life, along with environmental sustainability, increased safety and economic opportunity [3].

For cities, problems arise due to the fact that the city is managed under multiple separate domains with no real ability

to be condensed into one entity [3]. City managers have no single place to interact in real time regarding status or historical reports for city events. The physical systems of a city that need to be monitored include roads, energy, water, and sewer lines; but there is a lot of intangible data that, when analyzed and combined with other factors, provide critical, additional insight. Since the core of a city is composed of different networks, infrastructures and environments related to key functions including services, citizens, business, transport, communication, water and energy, public safety, health and education are central to whether a city offers up the quality of life desired by citizens smart [4]. Simply put, the daily operations of cities generate vast amounts of data from a multitude of sources that create an inability to visualize and extract meaningful information. Cities must address the increased number of service coordination and planning challenges as a result of urban sprawl [5]. Citizens face healthcare threats including infant mortality and disease [1]. For businesses, cities must balance regulatory requirements with the need to decrease costly administrative overhead, not to mention the inefficient transportation systems, which continue to drive up costs [6]. Increasing communication and connectivity demands challenge the ability of cities to meet the needs of its citizens and businesses effectively [6]. Water resources fall victim to leakage, theft and poor quality; and current energy systems are often insecure and inefficient. As cities face these substantial and interrelated challenges, it becomes clear that the 'business as usual' model has become obsolete. The solution to these problems is to leverage information across all city agencies and departments and present the information in a single unified view on one platform. Coordinating resources to respond more immediately and effectively allows city organizations and agencies to anticipate and correct for problems, thus minimizing the impact of future disruptions.

A majority of developed societies are experiencing aging. However, in developing economies such as those in India and the Middle East, there are massive 'bulges' of young people working their way through the education and economic systems [7]. As noted in previous research, pressures are mounting on the capacity of existing systems and institutions to respond [1] New demands for learning, skills, investment, growth and jobs are testing the limits of many countries to respond quickly enough and with solutions that work and endure (Katsigiannis et al. 2014). Technology's ability to connect everything and everyone is shifting the way individuals learn, work, do business, innovate, and entertain themselves [7]. These are shifts that can easily be underestimated when they are overhyped and simplified; yet things are changing.

Productivity now demands innovation which, in turn, requires the mobilization of an entire ecosystem that includes a solid knowledge infrastructure, a highly skilled labor force, creative workplaces, business models built with both customers and competition in mind, and engagement of global supply chains [8]. Investing in creating a smarter core system for a city creates cost savings and increased efficiencies while positioning the city for long term economic growth [9]. The shift towards a knowledge-based economy has increased the need for superior talent in the city center embodied by higher education, training, skills, creativity and innovation capacity [10].

The increasing demand for more diversified workers is becoming a crucial contributor to economic growth [11]. Therefore, as cities begin to face increased competition for both highly skilled labor and a diverse mix of talent necessary for growth in a global market, the need to optimize core systems of a city plays a critical role in attracting both skills and innovation to the region, equating to better public service delivery and a better overall standard of living [1].

As previously mentioned, education is a focal point in a city's journey to becoming a 'smart city.' Yet, instrumentation does not always have to be hardware; it can also be people. An estimated 75% of the fastest growing occupations will require STEM related skills and knowledge (science, technology, engineering and math) [12]. The need for an increased emphasis on computer coding, computational thinking, problem solving and design thinking into pre-primary and primary educational institutions cannot be avoided. The learning, knowledge and teaching roles of universities and the enduring role of cities as spaces and places for commerce, creativity and community are both being challenged [6]. The relationship between smart cities and connected universities is increasingly important to drive growth, sustainability and inclusion for stronger and more resilient urban and regional economies [7]. Leaders from both educational and governmental institutions strive to meet rising expectations from students, communities and employers with limited and increasingly constrained resources. Education is the critical determinant of success for communities in the 21st century just as land was important to agrarian societies and capital investment was paramount for industrial economies. In the future, the education industry will continue to face evolving challenges in its relationships with constituencies. Trends for the future of education provide indicators of new models and signal significant changes to all segments of education and funders. As a result, a new and transformative paradigm that IBM calls the "educational continuum" has emerged.

What are the trends that are creating the educational continuum? IBM has identified five: technology immersion of students (requiring critical thought, information literacy, etc.), data analytics for analysis of student and institutional data and performance metrics (serving as a foundation for improving allocation of resources, creation/delivery of curricula, etc.), personalized learning paths (selection of individual learning opportunities), knowledge skills for service-based economies (job-based skills) and economic alignment (governments responding to growth opportunities). These five trends are dramatically affecting students, workers and institutions now; and their impact will continue to increase. Education systems that adapt and respond accordingly are critical to a successful return on government education investments. Those that can

best demonstrate their adaptability and responsiveness will be the ultimate winners in receiving favorable government treatment and funding. In the educational continuum, the vast majority of students will follow more dynamic and individualized courses throughout their lifetimes. Their courses of study would start with an emphasis on foundational skills then advance toward specialized competencies that correspond to their strengths, passions and employment opportunities and continually provide for retraining as the employment market changes As government leaders worldwide increasingly begin to view education as a key component to a sustainable foundation for economic recovery and long-term health, educational systems such as will transition from outcome metrics that assess the performance of individual institutions to measuring the efficacy of the entire system in contributing to economic goals.

It goes without saying that the increased use of mobile technology and devices for IT functions continues to grow. Consumer IT and cloud technologies have driven down the costs of hardware and software.

Computing services, storage and networking bandwidth are approaching prices that shift the balance from scarcity to abundance. This has changed the economic dynamic of IT to focus on the scarcity of other factors: power and cooling costs, IT supports staff, floor space, management time and others. The growth of bandwidth and Internet scale computing capabilities spell the end of distributed computing. Computing is shifting 'into the clouds' and will be available whenever, wherever it is needed.

Cloud computing uses a utility delivery model to improve user services, thereby lowering costs because companies no longer need to acquire and maintain storage and computing power to run cloud applications. In the future, institutions and communities will build their own private clouds to provide unique services to their constituents. Cloud computing will enable educational institutions and governments to create shared services that can span regions and systems. According to [25] this will improve access to both urban and rural communities, improve the quality of services from providers, reduce duplication, and enhance efficiency.

3. Conclusion:

Smart city is a "booming" phenomenon, which is still ambiguous in literature. Many different sciences look into the smart city domain and this can be met both in the academia (from the involved journals, schools and scholars) and the industry. Almost all sciences can be met in the smart city domain, which approach this phenomenon from different perspectives. Scholars and schools across the world are being or have been investigated this phenomenon and an indicative "picture" is provided. On the other hand, three alternative industries appear to meet in this domain and create an emerging corresponding market: the ICT; the construction; and the electronics.

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